# Space Weather Technical Forecast

Issued on Monday, 22 May 2023 at 01:27 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: R1/R2 radio blackouts likely. G1 Minor/G2 Moderate storms likely day 2 (23 May). Active fluence likely by end of day 4 (25 May)**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Moderate with peak flare of M2.6 at 21/1604UTC from AR3311, a complex region in the northeast quadrant, which contains a delta spot. This region also produced an M1.4 at 21/0223. Ongoing development has been observed in this region, with both spreading and breaking of its larger spots, but also a further increase in the number of smaller spots. AR3305 is now rotating over the west limb, and was the source of a C9.8 flare at 21/2213. AR3310 is a large region in the southeast, however this is a stable and simple spot with little activity observed. The other regions are all smaller and simple to give at total of eight sunspot regions on the disc. No Earth-directed CMEs have been observed in the past 24 hours.

**Solar Wind / Geomagnetic Activity:** The solar wind, as measured at L1 declined from elevated speeds of 550-600 km/s to around 450 km/s. This then gradually rose from 21/1300 UTC to reach 550-600 km/s again. This was due to a combination of a weak CME arrival, perhaps from 17 May, and a SSB crossing into slightly elevated winds from an unknown source. Density was below average, but rose around 21/1430 to be around average. The total magnetic field strength Bt, was weak at first, but rose to from 21/1300 UTC to peak at 21/1510 UTC at 13nT. The north-south component, Bz, was mainly negative, and reached a minimum value of -10nT at around 21/1940 UTC. Phi angle was initially negative (towards the Sun) but rotated to be positive (away from the Sun) from 21/2200 UTC. Geomagnetic activity was initially quiet to Unsettled, but rose to give G2/Moderate storms (Kp6) 1800-2400 UTC.

**Energetic Particles / Solar Radiation:** High energy proton flux (greater than 10MeV), as measured at GOES16 has remained at background levels throughout. High energy electron flux (greater than 2MeV), as measured at GOES16 was mainly at background levels, but briefly rose to from 1400 UTC to peak at High, reaching 1080 pfu at 1455 UTC. The 24-hour integrated fluence has been well below Active levels. At 22/0000UTC, 1.49e7 integrated pfu was recorded.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is expected to be mainly Moderate, with a slight chance of High activity, due to either multiple M-class flares, or a chance of X-class flares. The main risk region is AR3311 in the northeast quadrant, which has produced multiple M-class flares in the last 48 hours.

**Solar Wind / Geomagnetic Activity:** There are no Earth-directed CMEs. Current elevated solar winds are expected to gradually ease on day 1 (22 May) before the onset of a further enhancement from the arrival of the fast wind from CH06/-. This is expected on day 2 (23 May), with solar winds likely to peak around 600 km/s, and only gradually easing later in the period. Further G1/Minor storms are possible early day 1 (22 May) before geomagnetic conditions likely ease to Quiet to Unsettled with chance of Active. Fast wind arrival later day 1 or more likely day 2 (22-23 May) is then expected to give Active to G1 Minor Storms, with a chance of isolated G2 Moderate storms. These conditions easing through day 3 and day 4 (24-25 May) to be mainly

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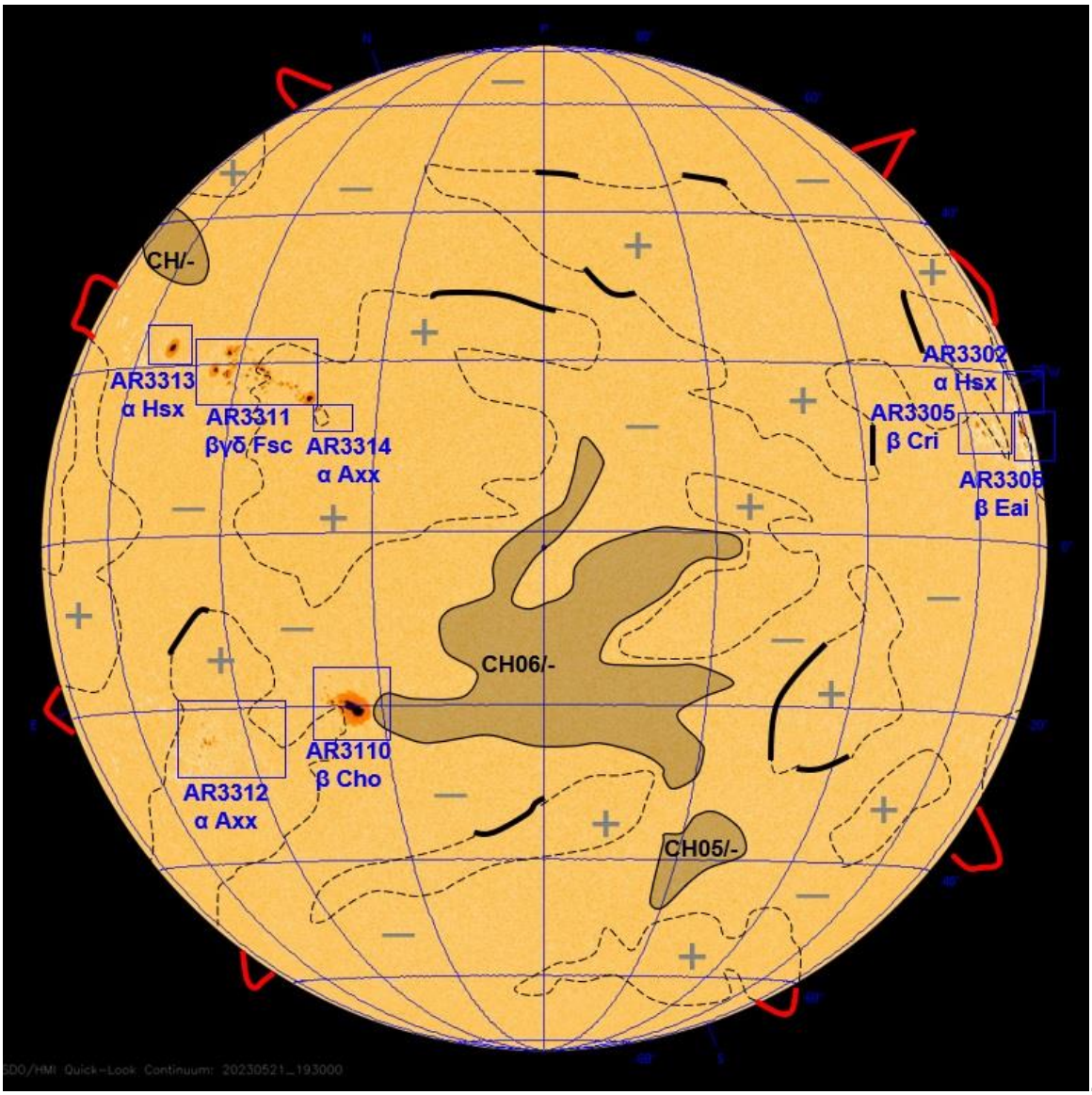
Quiet to Unsettled with Active intervals.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to be at background, but carries a chance of rising in response to any large flares that occur, and a slight chance of reaching the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) will likely rise, erratically at first, but more persistently day 3 and 4 (24 and 25 May). This will give a likelihood of reaching the Active threshold by the end of day 4 (25 May).

**Figure 1. Solar Analysis Valid 22/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

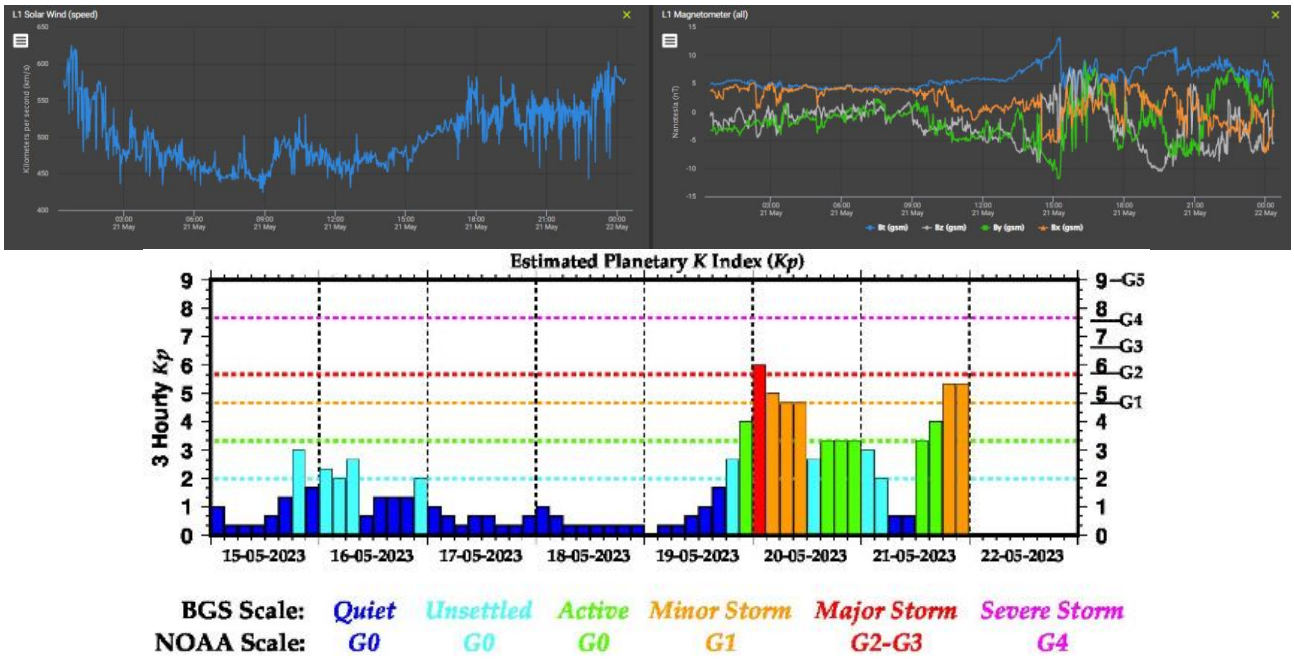
There are no Earth-directed CMEs.

Solar winds are currently enhanced due to the likely arrival of a weak and glancing CME which left the Sun on 17 May, that was embedded within a region of slightly elevated solar winds alongside a SSB (solar sector boundary) crossing. These slightly elevated winds are expected to gradually ease during day 1 (22 May) before rising again either later day 1, or more likely during day 2 (23 May) due to the arrival of the fast wind of CH06/-, likely reaching around 600 km/s. The fast winds are then likely to persist day 3, only slightly easing day 4 (24-25 May)

Initially Active geomagnetic activity, with a chance of further G1/Minor storms at first on day 1 (20th), before easing to Quite to Unsettled. CH06 fast wind arrival later day 1 or more likely day 2 (22-23 May) is then expected to give Active to G1 Minor Storms, with a chance of isolated G2 Moderate storms. These conditions easing through day 3 and day 4 (24-25 May) to be mainly Quiet to Unsettled with Active intervals.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | Yes | 30 | 60 | 30 | 1 |
| Strong | G3 | No | 1 | 5 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

**Figure 2: Current solar winds –Speed and Bt, with observed BGS Kp below**

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## Radio Blackouts - X-Ray Flares:

Complex region AR3311 in the northeast has stabalised to a degree, with its larger spots spreading and breaking into smaller regions to leave it longitudinally wide but comprised of a number of smaller umbral areas. Despite this, it has maintained a small delta amongst its intermediate spots, and was the source of the two M-flares on 20 May and continues to give a likelihood of further M-flares with a slight chance of X-class.

A further large region AR3305 is located on the northwest limb, and is soon to rotate off the visible disc, but also brings a chance of M-class flare activity. Another large, but simple spot, AR3310 is dominated by a single large and mature spot and is likely to remain stable without further development. The other five spots on the disc are much smaller, and less likely to give notable flare activity.

| X Ray Flares<br>Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| Active | R1-R2 M Class | Yes | 60 | 60 | 60 | 60 |
| Very Active | R3 to R5 X Class | No | 20 | 20 | 20 | 20 |

**Figure 3: GOES-16 X-ray flux**

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## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at background levels throughout and is expected to remain as such throughout the period. There is the potential for some enhancement due to any flare activity from the sunspots that are currently rotating onto the western horizon, or from the complex region AR3311.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 10 | 10 | 10 | 10 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) as observed at GOES-16 is currently at background, likely due to increased solar wind pressure constraining the outer Van Allen Belt to inside of GEO, as a consequence of the weak CME and slightly elevated solar winds. Recent enhancement have likely increased electron populations however, and as solar winds ease day 1 (22 May) Moderate to High flux can be expected for a time. The onset of the fast wind of CH06 is likely to further constrain the belt inside GEO however giving a further period of mainly Background flux day 2 and into day 3 (23-24 May). Flux levels are then expected to rise again as any geospace disturbance eases, reaching Moderate to High, likely persistently High, by day 4 (25 May).

The associated 24 hour electron fluence is expected to remain below the Active threshold until perhaps day 3, but more likely day 4. This is supported by REFM which is currently giving reasonable guidance.

| GEO Electron Environment Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 5 | 10 | 30 | 60 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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